Chapter 2
Scatter Plots and Introduction to Graphing

2.1 Scatter Plots

Relationships between two variables can be visualized by graphing data as a scatter plot. Think of the two list as ordered pairs. An ordered pair (x, y) can represent a point on a graph.

Example 1
In Table 2.1 are the SAT and math placement scores of ten randomly selected freshmen students. Graph the data to see if a relationship exits between the SAT scores and the math placement scores.

SAT	**600**	**640**	**430**	**500**	**510**	**530**	**550**	**370**	**500**	**530**
Math Place	**25**	**29**	**14**	**12**	**11**	**8**	**17**	**16**	**9**	**26**

Table 2. 1

> **Note**: Refer back to Chapter 1 Sections 1.1 through 1.4 for information on entering data into lists.

2.1.1 Enter the Data

CLEAR List 1 (L1)and List 2 (L2).
Enter the math placement scores into L1.
Enter the SAT scores into L2 (see Fig. 2.1).

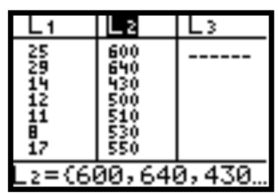

Figure 2. 1

2.1.2 Set Up the Scatter Plot

Press 2nd STATPLOT . Select [1:Plot1].
Set up the Scatter Plot as in Fig. 2. 2 or 2.3.

Figure 2. 2
TI-82 Plot1 setup.

Figure 2. 3
TI-83 Plot1 setup.

2.1.3 Size the Window

Press WINDOW ∇ . Set the appropriate window based upon the data in L1 and L2, as in Figure 2.4.
The **X list** contains the math placement scores and the **Ylist** contains the SAT scores, so the window is set just beyond the lowest and highest data values.
X: [Xmin, Xmax] = X: [6, 32] and
Y: [Ymin,Ymax] = Y: [340, 670].

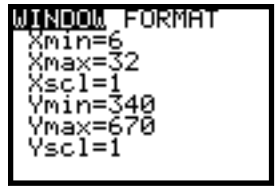

Figure 2. 4

To view the Scatter Plot press GRAPH (see Fig. 2.5). There appears to be an increasing relationship, i.e. as the math placement score increases the SAT score increases, but there are a few exceptions (outliners).

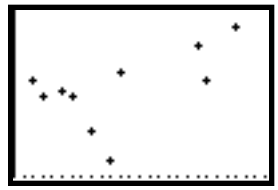

Figure 2. 5

Math placement on the *x*-axis.

2.1.4 Switch the *x* and *y* Variables.

What does the plot look like when L2, the SAT score, is the independent variable? Set up the plot as in Figure 2.6 or 2.7.

Figure 2. 6 TI-82 Plot1 setup.

Figure 2. 7 TI-83 Plot1 setup

2.1.5 Sort List 2 and List 1 Together

To sort List2 while keeping the pairing with List1, Press STAT , select [2:SortA]

2nd L2 , 2nd L1) ENTER ;
(see Fig. 2.8).

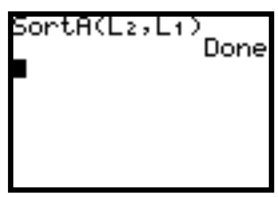

Figure 2. 8

2.1.6 Setting the Window

Look at the sorted list (Fig. 2.9). Press STAT ; select [1:Edit]. Use the sorted List2 to determine the window setting . Remember we want L2 to be the independent variable. The window is set just beyond the lowest and highest data values. X: [350, 660] and Y: [0, 35].

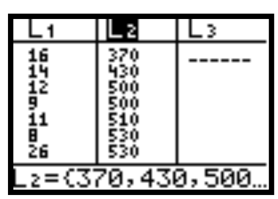

Figure 2. 9

Press WINDOW ∇ . Set the window as in Figure 2.10.

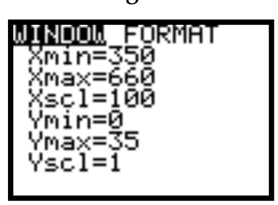

Figure 2. 10

<u>**Note**</u>: There are many correct window sizes. Choose a window that will contain all of the points and slightly beyond the points.

Trouble Shooting: Before you press graph:

1. Clear [Y=] or turn **OFF** all graphs. To turn off graphs, place the cursor on the = sign then press [ENTER] .
2. Turn **OFF** all plots except the one you want to see.

ERR: INVALID DIM means your lists are not the same size, you have selected a list with no data in it or you have a plot turned on that you did not want and it has different size lists.

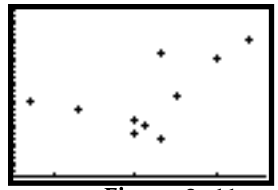

Figure 2. 11
SAT on the *x*-axis

Press [GRAPH] (see Fig. 2.11). Here the relationship is less clear. Perhaps more data is necessary to determine a trend or relationship. Explore the plot using **TRACE** (see Fig. 2.12).

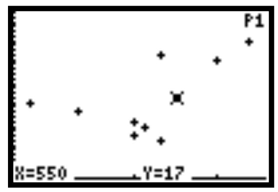

Figure 2. 12

2.1.7 A Check List for Plotting

To plot statistical data in lists, follow these steps:

1. **Clear old data in lists.**
2. **Store the statistical data in one or more lists.**
3. **Set up the STAT PLOT.**
4. **Turn Plots ON or OFF as appropriate. (see Fig. 2.13).**
5. **Clear or deselect [Y=] equations as appropriate (see Fig. 2.14).**
6. **Define the viewing WINDOW.**
7. **Explore the plot or graph by pressing TRACE (see Fig. 2.12).**

Figure 2. 13

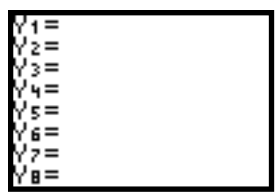

Figure 2. 14

2.2 Introduction to Graphing Functions

The graphing calculator can be used to graph equations that are functions. The top row of keys, under the viewing screen , contains all the graphing menus.

Note: Before you begin graphing

1. Turn all plots **OFF**: [2nd] [STATPLOT] select [4 :PlotsOff] [ENTER] (see Fig. 2. 13). The calculator will say ***Done***. .
2. Press [Y=] and [CLEAR] all equations (see Fig. 2.14).

2.2.1 The Standard WINDOW

Press [ZOOM] select [6:Zstandard] (see Fig. 2.15). The graph screen and the ***x y*** coordinate system appears (see Fig. 2.16).

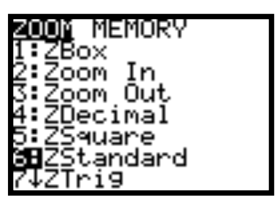

Figure 2. 15

You see only a portion of the real number line on the xy-coordinate plane. The size of the viewing window is determined by the window variables : **Xmin, Xmax, Ymin,** and **Ymax** (see Fig. 2.17).

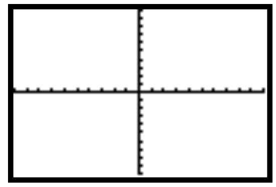

Figure 2. 16

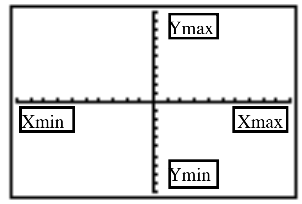

Figure 2. 17

(The words will not appear on your screen)

To see the current ***Standard Window*** , press WINDOW (see Fig. 2.18).

The distance along the X-axis goes from -10 to 10 or X: [-10, 10]. The distance along the Y-axis goes from -10 to 10 or Y: [-10, 10]. The distance between the tic marks on the ***x***-axis is 1 unit (Xscl = 1) and the distance between the tic marks on the ***y***-axis is 1 unit (Yscl = 1).

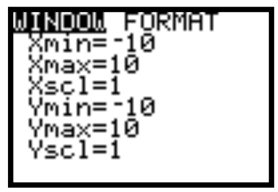

Figure 2. 18

2.2.2 The Free Moving Cursor

Press GRAPH . When you press the arrow keys, ▷ ◁ Δ ∇ , the cursor can move anywhere on the graphing window. The cursor has changed to a cross and at the bottom of the screen you see the coordinates of the screen position, which change as you jump form pixel to pixel. A pixel is a point of light on the screen (see Fig. 2.19).

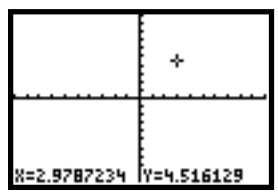

Figure 2. 19

2.2.3 The Decimal Window

Notice that on the standard window you get rather “ugly” decimals when you press the arrow keys.

Press ZOOM ; select [4:ZDecimal].

Now press the arrow keys. As you jump from pixel to pixel you increment by the decimal value 0.1 (1/10) (see Fig. 2.20).

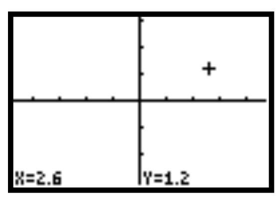

Figure 2. 20

Press WINDOW to see the decimal window settings for ***x*** and ***y*** (see Fig. 2.21).

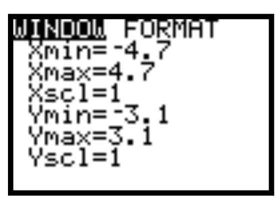

Figure 2. 21

Example 2
To change Centigrade temperature to Fahrenheit use the formula F = (9/5)C +32.
Enter this formula into the calculator and graph the function.

Press **Y=** ; into **Y1** type **(9/5)** ***x*** **+ 32**.
(see Fig. 2.22 or 2.23).

> **<u>Trouble Shooting</u>:** The independent variable, in this case C, must be entered as X on the calculator. The dependent variable F will become Y. Notice you can graph 10 different functions, Y1 to Y10.

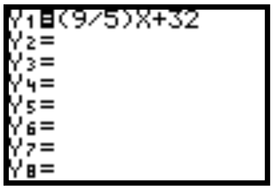

Figure 2. 22

The TI-82 Y= Screen

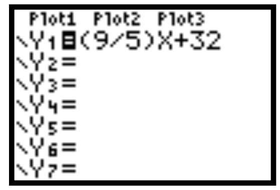

Figure 2. 23

The TI-83 Y= Screen

<u>A Special Note to TI-83 Users.</u>

Plots can be turned **ON** and **OFF** from the Y= screen. To turn a plot ON, use the arrow keys to position the cursor on the desired plot name (Plot1, Plot2, Plot3), then press ENTER . To turn the plot OFF press ENTER . Darkened plots are ON.

2.2.4 The Integer Window

Press WINDOW ∇ , then set the window to the settings as in Figure 2.24.

Press GRAPH , then TRACE . Right arrow to 8° C to see the equivalent temperature 46.4° F (see Fig. 2.25). Left arrow to -10° C for the equivalent 14° F (see Fig. 2. 26). Notice the pixel jumps are now integers of two units. Play with the arrow keys as you TRACE on the function.

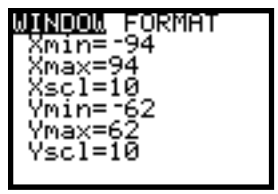

Figure 2. 24

Friendly Windows

As you move in an x direction from pixel to pixel there are 94 jumps across the screen. Likewise there are 62 pixel jumps in a y direction. To determine the horizontal jump, Δx, and the vertical jump, Δy, use the following formulas:

$$\Delta x = \frac{x_{max} - x_{min}}{94}$$

$$\Delta y = \frac{y_{max} - y_{min}}{62}$$

<u>**Note**</u>: A “Friendly Window” is any window whose distance between **Xmax** and **Xmin** is evenly divisible by 94. In the above window Δx = (94 - (-94)) / 94 = 2, or two units per each x pixel jump.

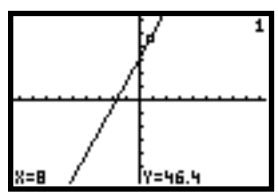

Figure 2. 25

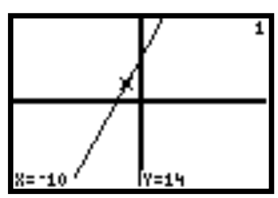

Figure 2. 26

2.2.5 Use Table to Help Find the Appropriate Window.

Finding the appropriate window for a function takes a lot of practice. The following tips can be very helpful:

1. Use algebra to calculate a few easy values of y, such as when $x = 0, 1, -1$ etc.
2. Press [TRACE] to discover where a few points lie on the graph.
3. Use [2nd] [TABLE] to see many values of x and y.

Example 3
Find an appropriate window for
$f(x) = y = x^2 + 25$

Press [**Y=**] ; into **Y1** type: $x^2 + 25$ (see Fig. 2.27). Press [ZOOM] ; select [6:ZStandard]. No graph is seen (see Figs. 2.28 and 2.29).

Algebra tells us that when $x = 0$, $y = 25$. On the standard viewing window the y values are Y: [-10, 10], so $y = 25$ cannot be seen!

Press [TRACE] ; hold down [▷] to confirm that y is larger than 25 (see Fig. 2.30). Press [2nd] [TblSet] . Begin the table at $x = -5$ and increment by 1 unit ($\Delta tbl = 1$). Set up a table of values as in Figure 2.31 . Press [2nd] [TABLE] . Use [▽] to scroll through some values (see Fig. 2. 32).

An appropriate window based upon the table appears to be X :[-10, 10] and Y: [-10, 50] or better still Y: [-10, 100], with Yscl = 10 (see Fig. 2.33).

<u>Trouble Shooting</u>: To lessen the trial and error process for finding an appropriate viewing window, always use **TRACE** and **TABLE** to find points on your graph. Usually it is the Ymax that needs to be adjusted not Xmax.

Figure 2. 27

Figure 2. 28

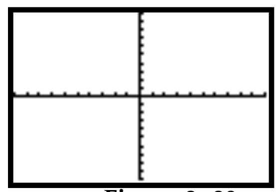

Figure 2. 29

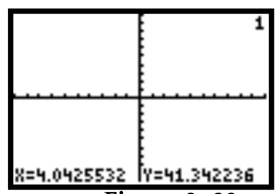

Figure 2. 30
TRACE reveals points on the graph.

Figure 2. 31

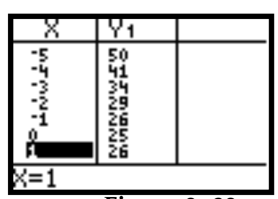

Figure 2. 32

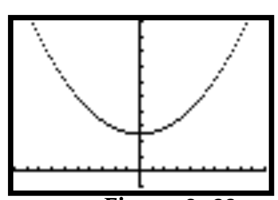

Figure 2. 33
X: [-10, 10] and Y: [-10, 100]

2.3 Using Graphs To Determine the Domain of a Function

For most functions the ***domain*** (possible x values) is all real numbers. However there are functions that are the exception.

Example 4
Use a graph and a table of values to help determine the domain of the function
$f(x) = y = 1/x$.

Press [**Y=**] [CLEAR]. Into Y1 type **1** / x (see Fig. 2.34). Press [ZOOM]; select [4:ZDecimal] [TRACE].

Figure 2. 34

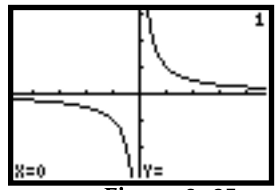

Figure 2. 35
y is undefined for $x = 0$

We see a graph in two pieces. TRACE is telling us that there is no y value associated with $x = 0$ (see Fig. 2. 35).

Set up a table of values. Press [2nd] [TblSet]. Begin the table at $x = -5$ and increment by 1 unit (Δtbl=1) (see Fig. 2.36). Press [2nd] [TABLE]. Notice that for $x = 0$ we get an ERROR message, which means that y is undefined for $x = 0$ (see Fig. 2.37).

Figure 2. 36

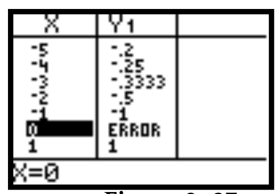

Figure 2. 37

Both the graph and the table confirm that $x = 0$ is not in the domain of x. The domain of $f(x) = 1/x$ is the set of all real numbers x, $x \neq 0$. Using interval notation:

$(-\infty, 0) \cup (0, +\infty)$

Example 5
Use a graph and a table of values to help determine the domain of
$f(x) = y = \sqrt{x}$

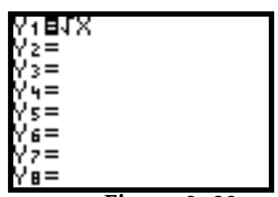

Figure 2. 38

Press [**Y=**] [CLEAR].

Into Y1 type [2nd] [√] [X,T,Θ].

Press [GRAPH] [TRACE].

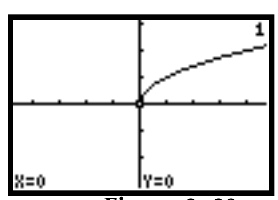

Figure 2. 39

The function $f(x)$ appears to be defined for $x = 0$, but not to the left of zero, $x < 0$ (see Figs. 2.39 and 2.40).

The domain of f(x) = $\sqrt{x}$ is the set of all real numbers $x \geq 0$ or x: $[0,+\infty)$. Confirm with a table of values.

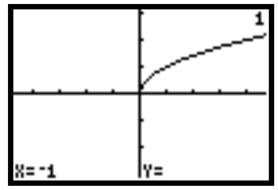

Figure 2. 40

Press [2nd] [TABLE] . Notice that values for x less than 0 give an ERROR message, which means the function is undefined for $x < 0$ (see Fig. 2.41). Use [∇] to see other values of y that are defined by x.

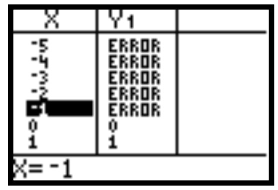

Figure 2. 41

This helps confirms that the domain of the square root function is the set of all x such that $x \geq 0$, i.e., domain = $\{x \mid x \geq 0\}$.

2.3.1 Graphs that are NOT Functions.

Example 6

Graph $y^2 = x$

First solve for y. There are two values for y , $y = +\sqrt{x}$ or $y = -\sqrt{x}$, , therefore y is not a function. However, a relationship does exist between x and y. We need to trick the calculator into graphing the relationship.

Let **Y1 =** $\sqrt{x}$ and **Y2 = -**$\sqrt{x}$**.** (see Fig. 2.42).

Figure 2. 42

Press [GRAPH] (see Fig. 2.43).

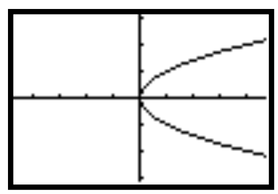

Figure 2. 43

In addition we can tell y is **not** a function of x because it fails the *vertical line test*.

> **NOTE**: The **Vertical line test** says if a vertical line intersects a graph at more than one point, the graph is not a function.

Press [2nd] [DRAW] ; select [4:Vertical] (see Fig. 2.44).

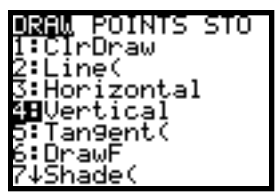

Figure 2. 44

Use the right arrow [▷] to position the vertical line on $x = 3$.

Since a vertical line intersects the graph in two places (i.e. there are two y values for one x value), the graph is **not** a function (see Fig. 2.45).

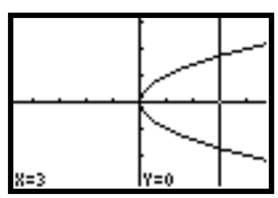

Figure 2. 45

(3, 0) are the coordinates of the x**-intercept of the vertical line**

2.3.2 Range and Graphs of Other Interesting Functions.

Example 7

1. Graph the absolute value function

f(x) = y = $|x|$

Press Y= and CLEAR all values from Y1.

*Type 2nd ABS (X,T,Θ) (see Fig. 2.46)..

> ***TI-83 Note**: The absolute value command is under MATH <NUM> [1:abs( ]. The left parentheses is provided, you type the right parentheses.

Press ZOOM ; select [4:ZDecimal].

The absolute value graph has the distinctive **"V"** shape. The absolute value of a number is a nonnegative value. Therefore, your output values (y values), or the ***range*** of the function, is $y \geq 0$.

2. Graph the absolute value function

g(x) = y = $|x + 2| - 1$

Press Y= into Y2 *type 2nd ABS (X + 2) -1 . (*TI-83 see above box) (see Fig. 2.48).

Press GRAPH TRACE ∇ . You are on Y2 .

Left arrow to x = -2 (see Fig. 2. 49). This reveals the lowest y value on the graph, or y = -1. The range for $y = |x + 2| - 1$ is:

$y \geq -1$ or $\{y \mid y$: $[-1, +\infty)\}$

3. Graph the greatest integer function :

h(x) = y = [[x]]

The **greatest integer function** denoted by [[x]], is defined as the greatest integer less than or equal to x. [[4.3]] = 4 and [[-2.7]] = -3. This is the interger to the ***left*** of the number. The graph is often referred to as a step function. To see the graph reset the calculator to **dot mode** (see Fig. 2.50).

Press Y= and CLEAR all expressions.

Press MATH <NUM> select [: int]. Your function should be typed as in Figure 2.51.

Press GRAPH . The distinctive step function appears. The domain for x is any real number, TRACE reveals that the range of y is always an integer (see Fig. 2.52).

> **<u>Note</u>: Remember to change back to connected MODE.**

Figure 2. 46

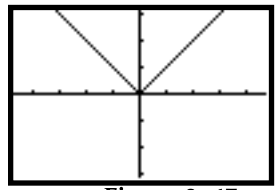

Figure 2. 47

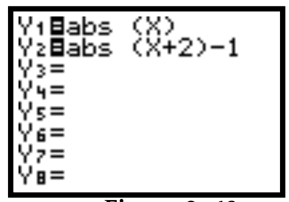

Figure 2. 48

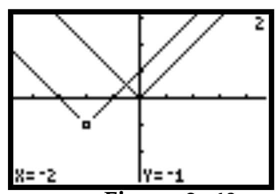

Figure 2. 49

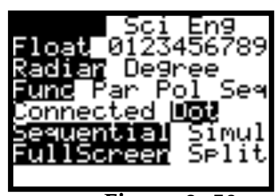

Figure 2. 50

Figure 2. 51

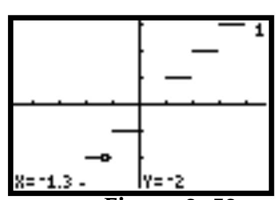

Figure 2. 52

The graph shown in Dot Mode